AIAA Plug-n-Play Mission Operations Workshop

Track 1-Approaches
Communication Architectures

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May 16-17 2011

Overview

- **Vulcan Wireless Background**
- **Communications Trade Space**
- **Small Satellite Solutions**
- **Hypersonic Flight Experiment**

Overview

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Company Background

- Located in Carlsbad California
- Formed in 1993, Incorporated in 1999
- Leverage COTS technology to Military Applications
- Digital Communications and Sensors
- Active SBIR Phase 1 and 2 Projects in SDR and Encryption Technology
- Focusing on Small Satellite Applications

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Communications Trade Space

- Requirements Drive Solutions
- High Level User Inputs
  - Data Rate
  - BER
  - Latency (Delay)
  - Availability
  - Vehicle Dynamics
  - Channel Characteristics
- One Communications Solution Does Not Fit All

CubeSat TT&C
- Low Data Rate
- Low BER
- Long Latency
- Low Availability
- LEO Vehicle

Sensor Telemetry
- High Data Rate
- Low BER
- Low Latency
- High Availability
- MEO Vehicle

Radar Sensor
- High Data Rate
- Low BER
- Low Latency
- High Availability
- LEO Vehicle

Multi Tier Market

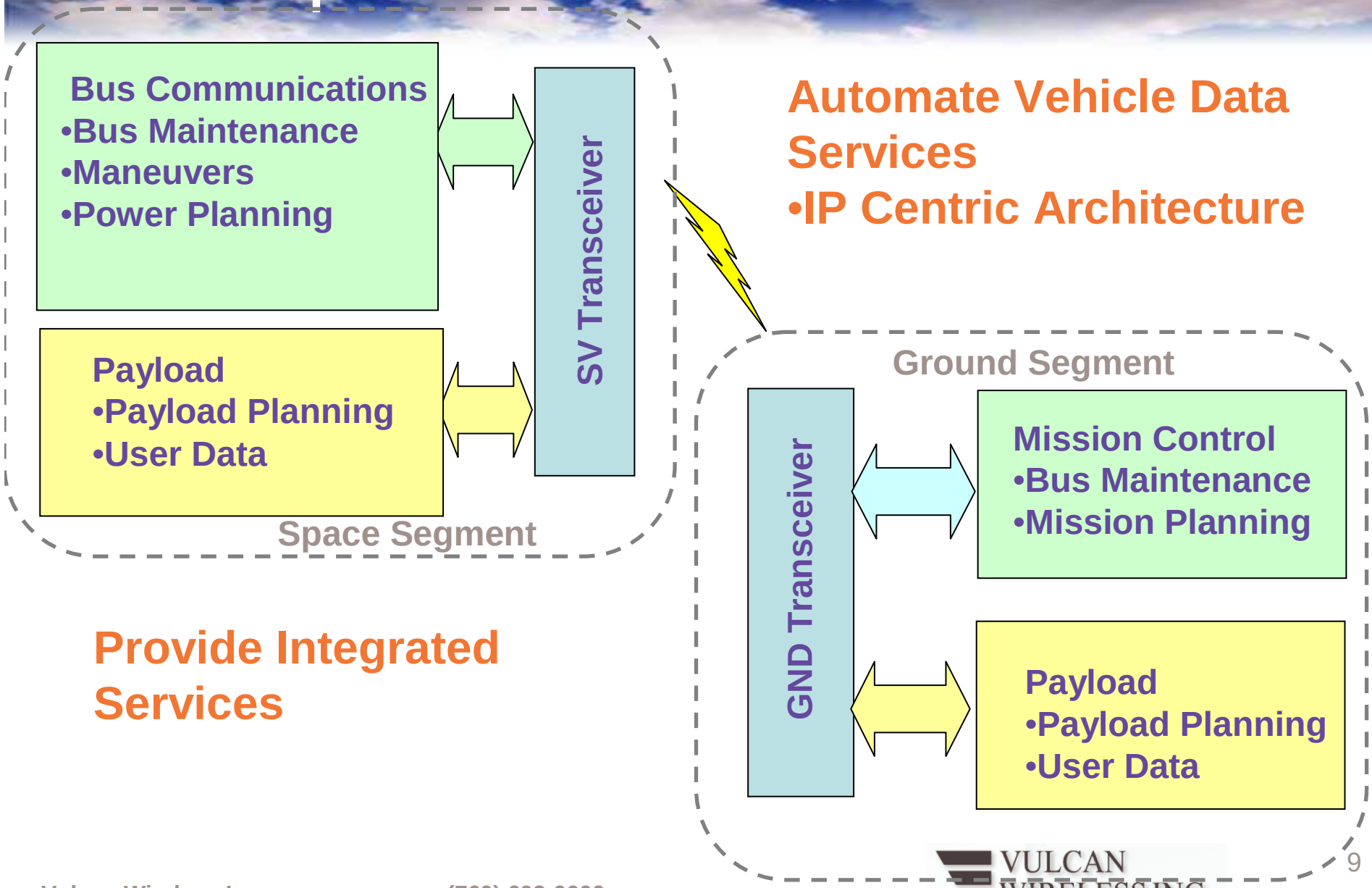
- University/Research Market
  - Labor is free
  - Materials budget drives program
  - Requirements are driven from this perspective
- Commercial Market
  - Labor is largest cost
  - Materials are basically free
  - Requirements are driven by $/bit and profit margin
- DoD Market
  - Labor cost are large
  - Hardware costs are significant
  - Requirements are driven by Lives/bit

- Its all about perspective

General Architectures

- High Availability (LEO/GEO, LEO/LEO)
- Low Latency (LEO/GND, LEO/LEO)
- Low Data Rate (LEO/GND, LEO/GEO)
- Medium Data Rate
- High Data Rate (LEO/GND, LEO/GEO)
- Low Cost (LEO/GND)

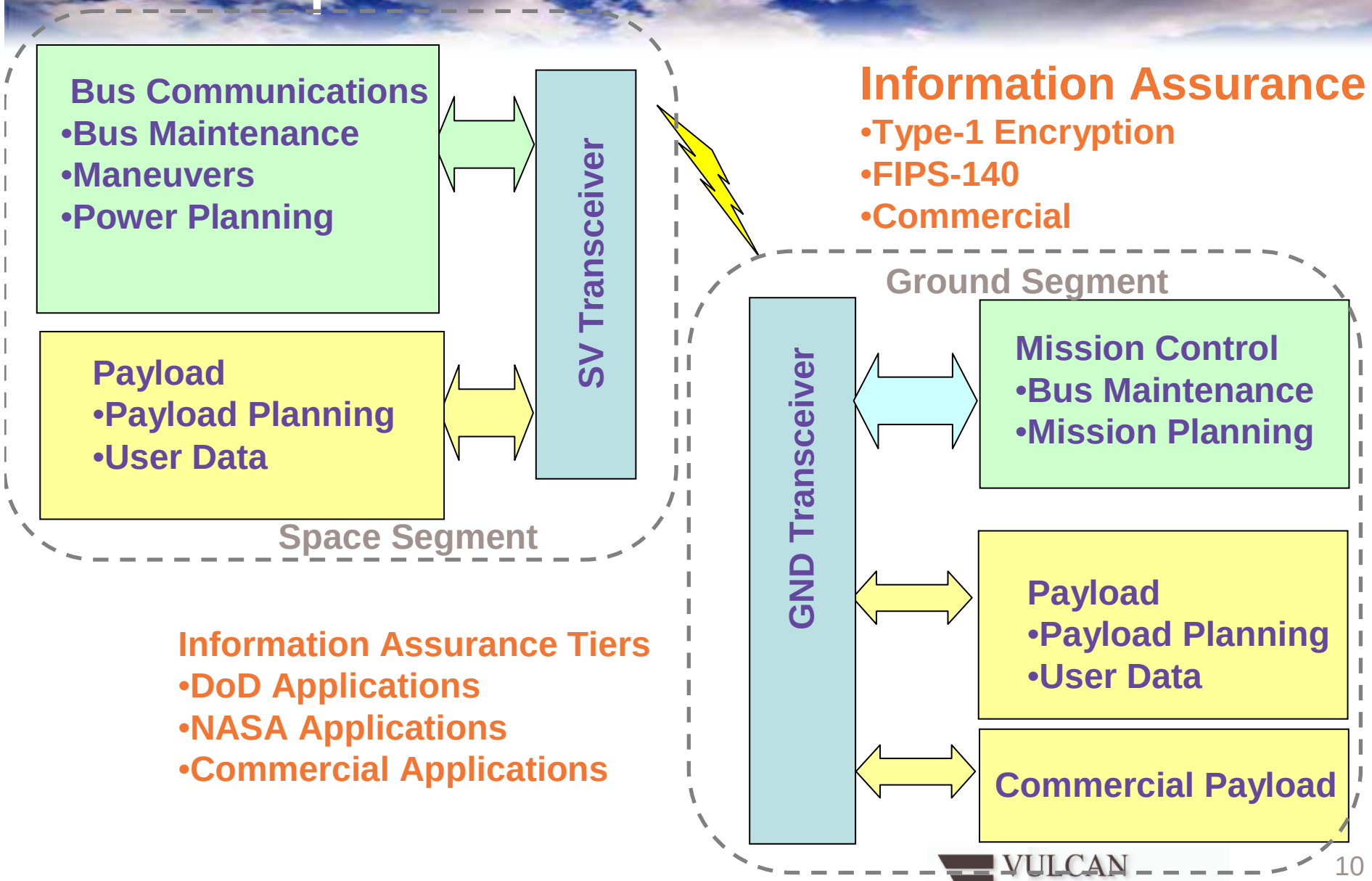
Space Communications



Automate Vehicle Data Services
•IP Centric Architecture

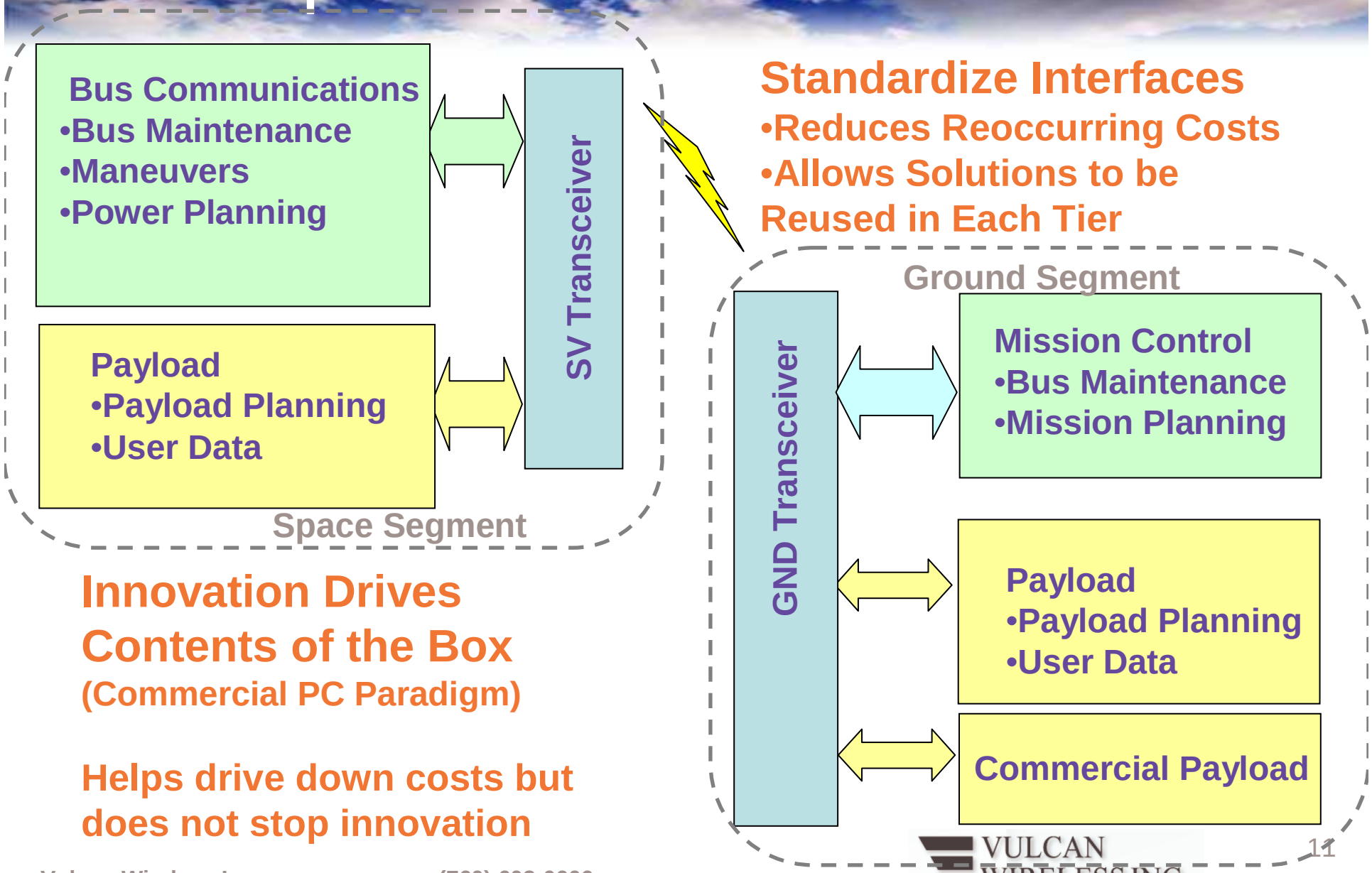
Provide Integrated Services

Space Communications



Information Assurance Tiers
- DoD Applications
- NASA Applications
- Commercial Applications

Space Communications

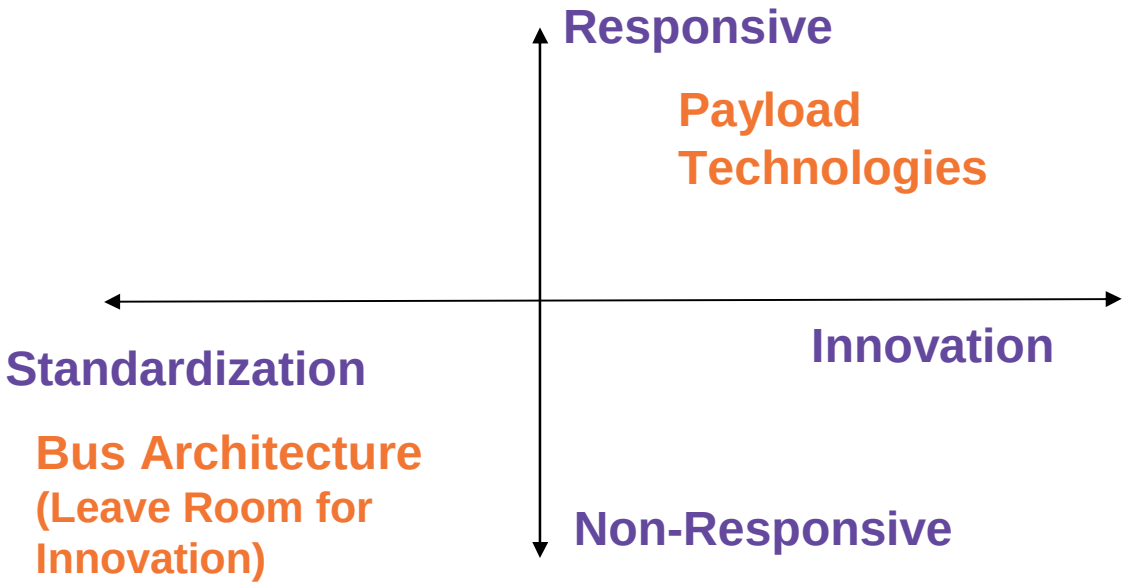


Innovation Drives Contents of the Box

(Commercial PC Paradigm)

Helps drive down costs but does not stop innovation

Innovation Vs Standardization



- Plug-and-Play SPA Architecture
  - SSM (Remote Procedure Call Mechanism)
  - ASIM (Communications Interface Device)
  - XTEDS (Electronic Data Sheets)
  - Goal to Commoditize Hardware Interfaces

CubeSat Clusters

- Spectrum Management
- Spectrum Sharing
- Spectral Reuse

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Small Satellite Communications Challenges

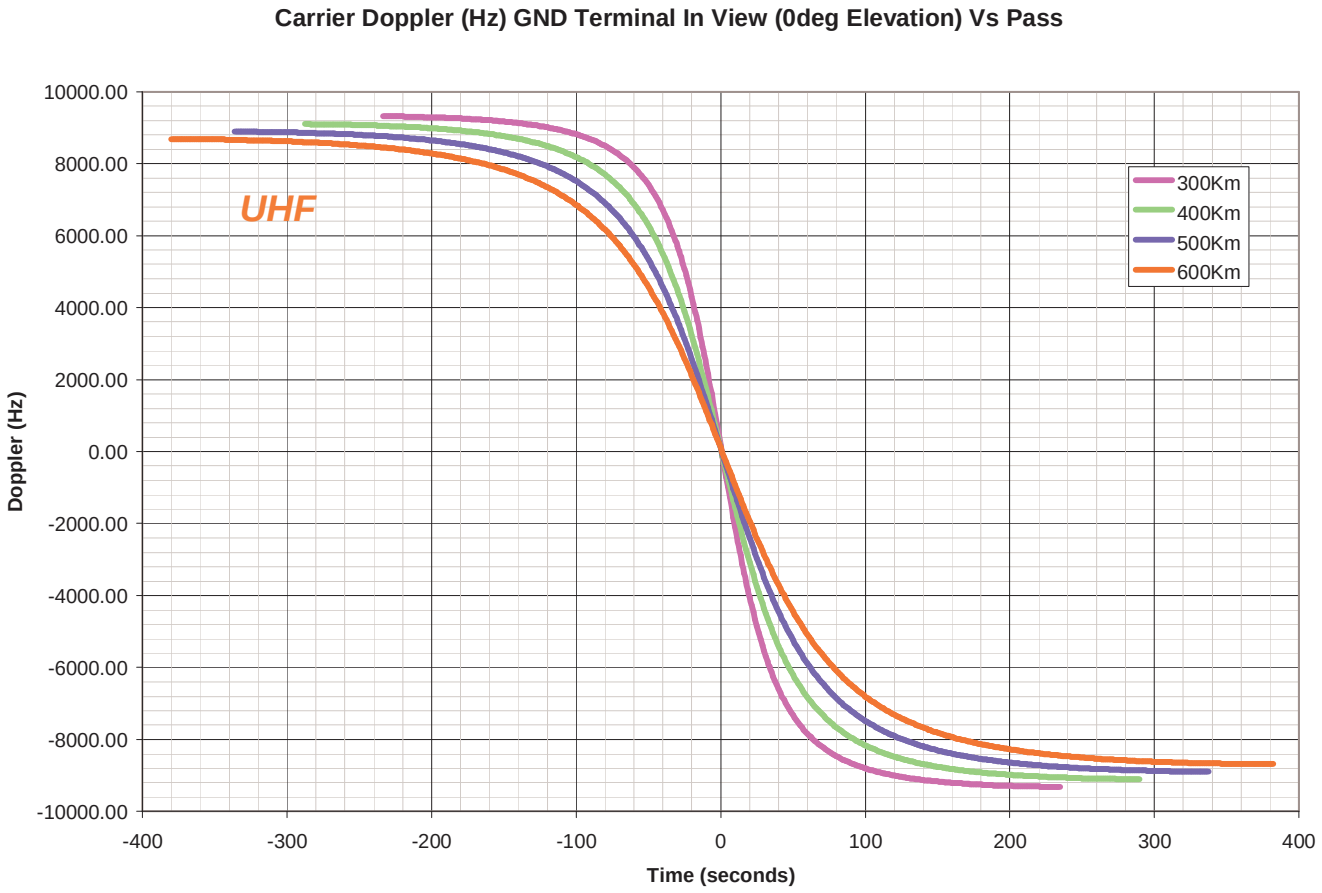
Solutions

- Low Power Footprint **Low Power Signal Processing**
- Small Physical Footprint **CubeSat Form Factor**
- Frequency Bands **UHF/L/S/X-Band**
- Waveforms **Programmable Waveforms**
- Ground System Compatibility **Multiple Protocols**
- Legacy Compatibility **Variable Waveforms and Protocols**
- High Doppler Offsets and Rates **On Orbit Doppler Correction**

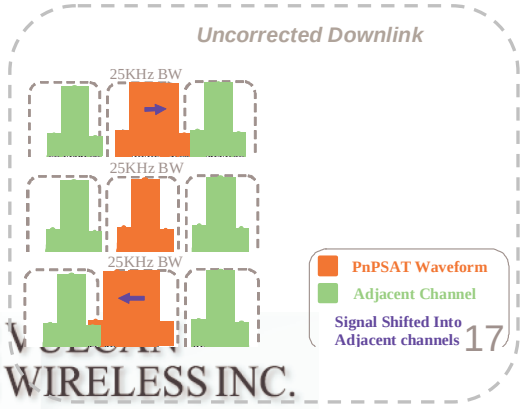
LEO SDR Challenges

- Doppler Offsets: Rapid Carrier Estimation
- Rapid Waveform Acquisition: Enables Packet Switchable Waveforms
- Flexible Waveform Demodulation
- Flexible Forward Error Correction
- Mitigates Fading Channels
- Programmable AGC Dynamics
- Programmable Data Rates

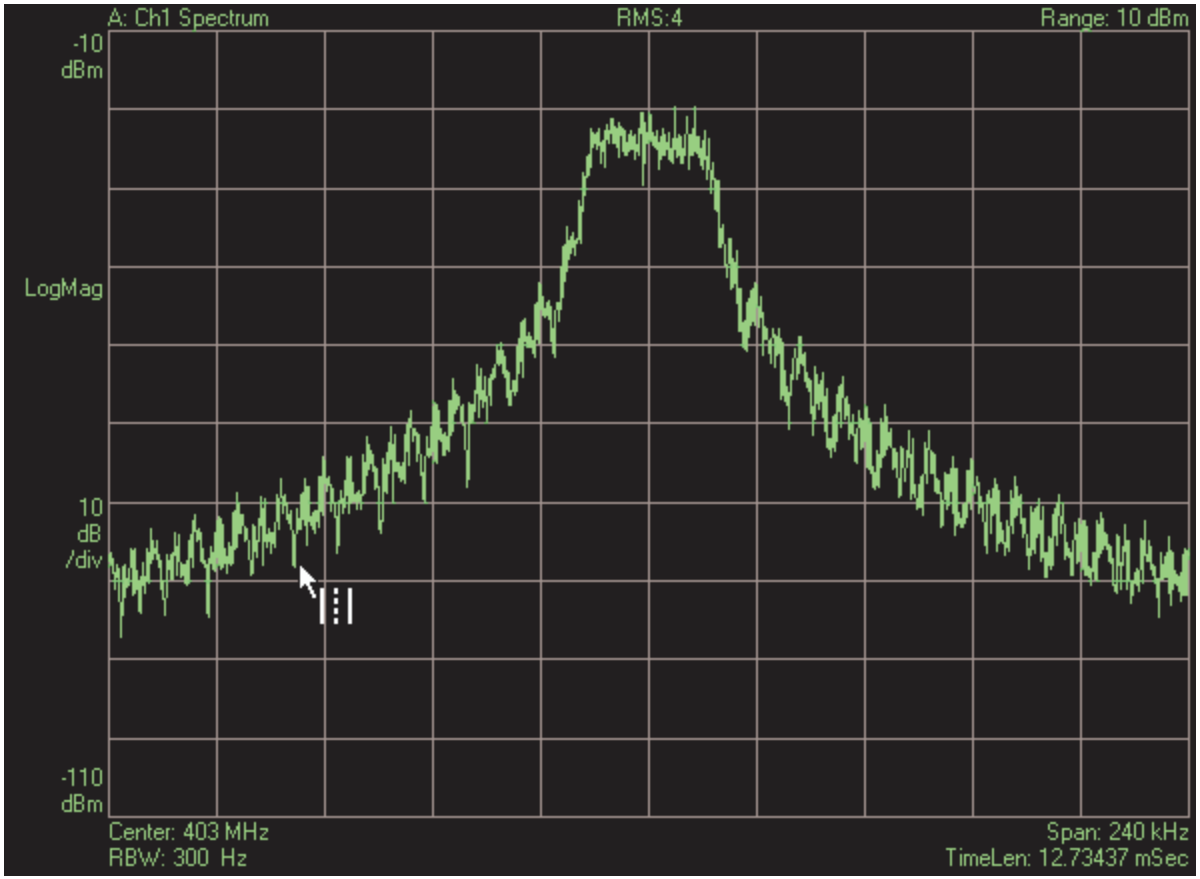
Doppler Frequencies Vs SV Altitude



Carrier Doppler [Direct Overhead Pass]



Transmit Waveform Example Spectrums



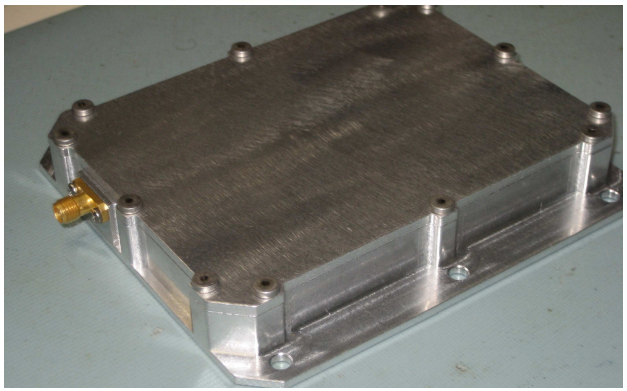
CSR-SDR

Multi-H CPM (12/13) 19.2Kbps (Mode 137)

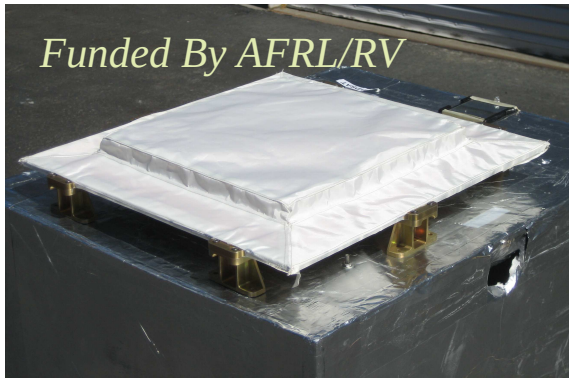
Hardware Solutions

- MBT-R2 and PnPSAT
- CSR-SDR (UHF/S-Band)
- USB-SDR (USB S-Band)
- DBT-SDR (S-Band SEW)
- LPR-SDR (Low Power S-Band)

MBT-R2 PnPSAT



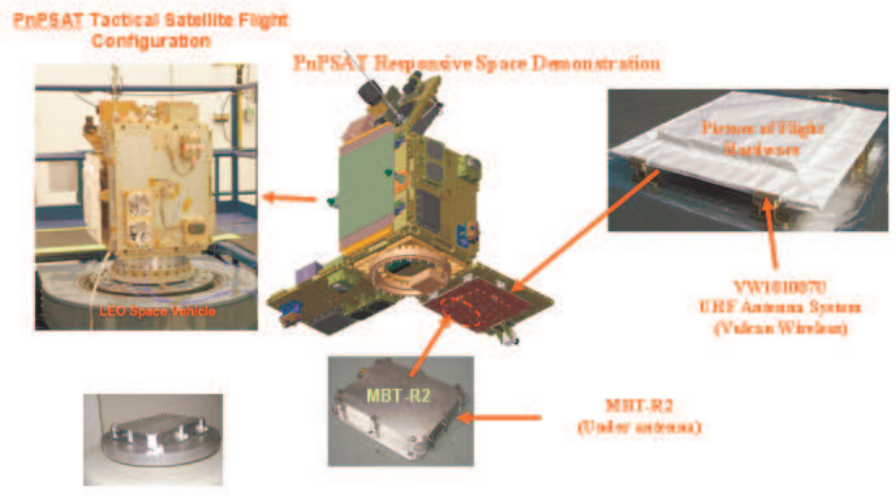
MBT-R2 Tactical SDR



PnPSAT UHF Flight Antenna

GTX117 Ground Terminal

- Developed for PnPSAT
- UHF Tx/Rx Half Duplex
- Software Defined Radio Flexibility
  - TT&C
  - Direct to War Fighter
- Integrated 28V Power Supplies
- Provided Turn Key Data Link with:
  - SDR (Tested to TRL-6)
  - Flight Antenna
  - Tracking Ground Terminal (Kwaj)



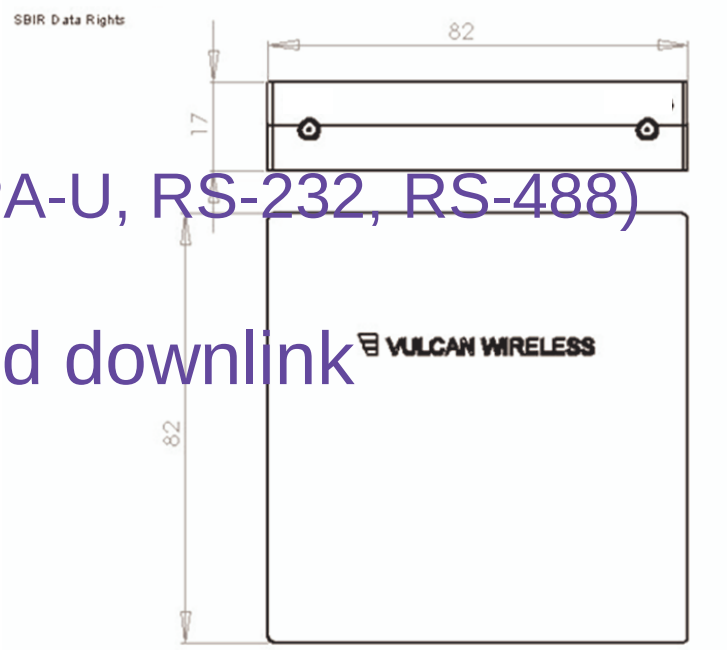
Tactical UHF Communications Payload Flight Hardware

VULCAN WIRELESS INC.

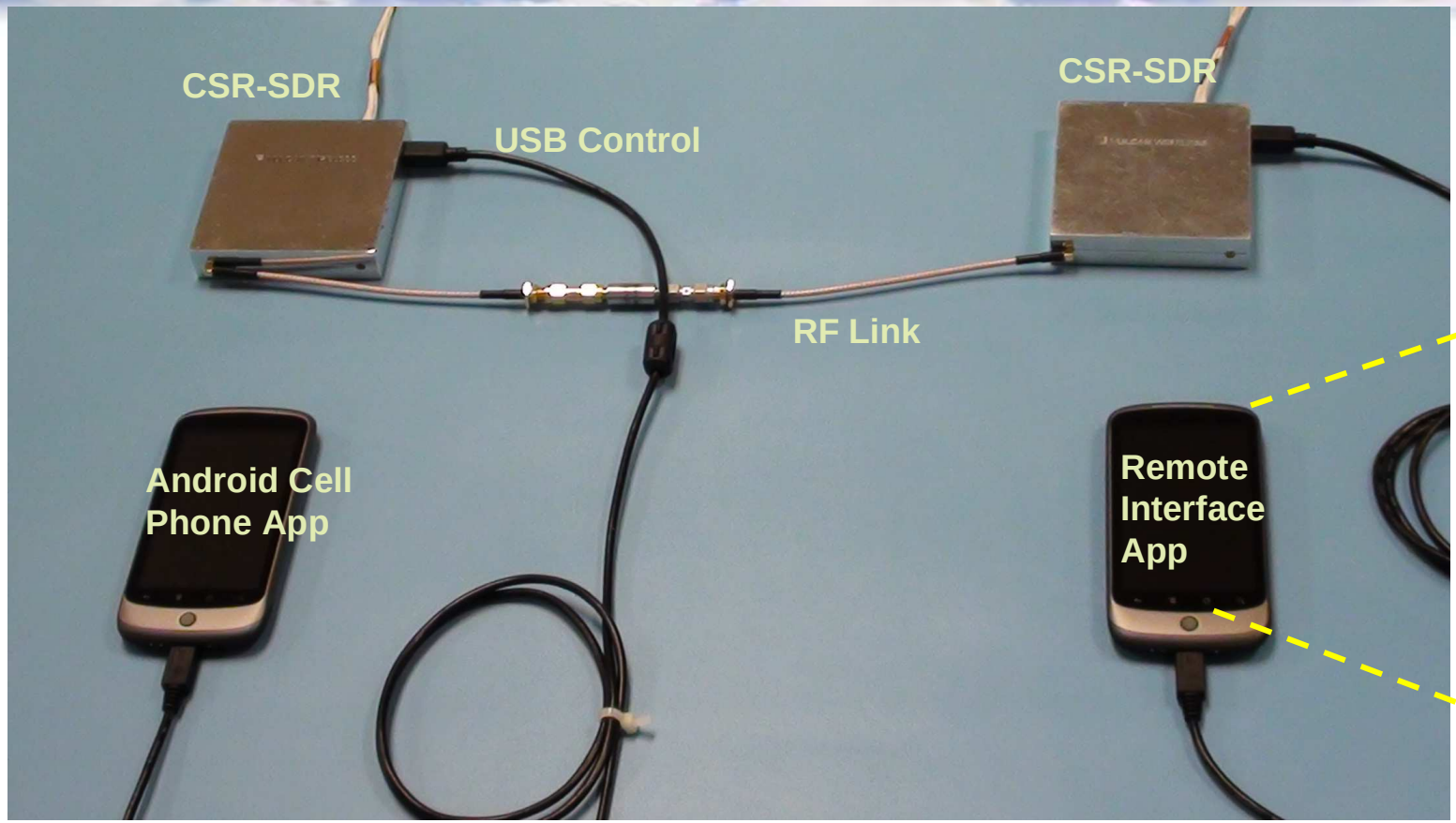
Vulcan Wireless Inc. (760) 602-0606

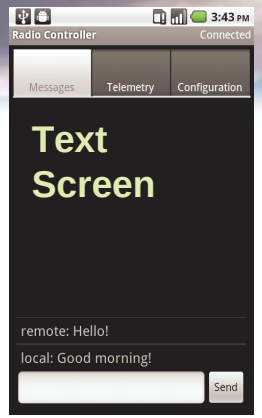
CSR-SDR

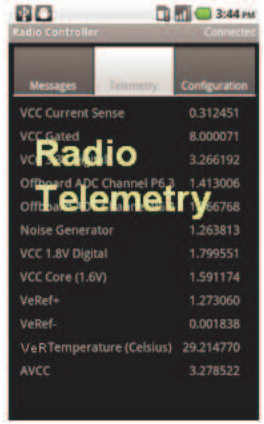
- UHF Tx/Rx Half Duplex
- CubeSat Form Factor
- Software Defined Radio Flexibility
  - TT&C
  - Direct to War Fighter
- Integrated Power Supplies
- Multiple Interfaces (SPA-1, SPA-U, RS-232, RS-488)
- Flight Tested (TRL-7)
- Integrated high speed S-Band downlink
  - TDRS-MA
  - High Speed Telemetry

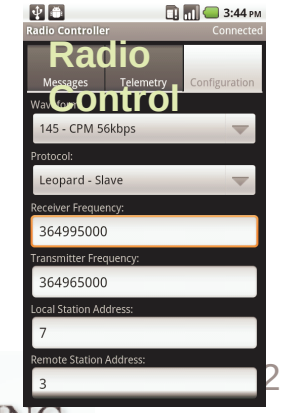


CSR-SDR Android Demo





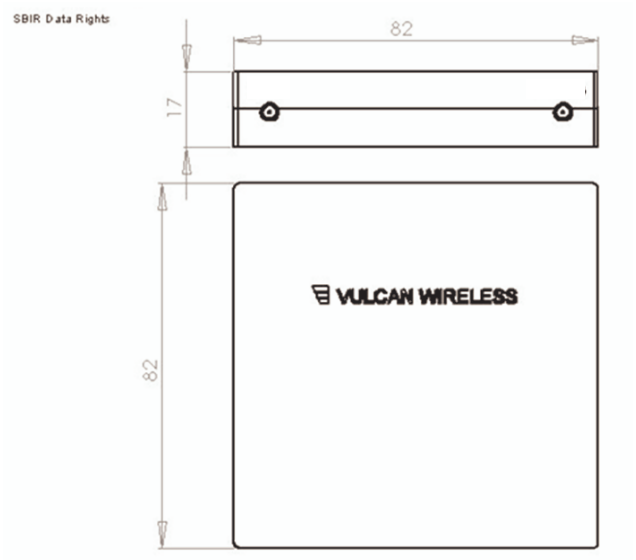




- Demonstrated UHF Bidirectional Communications with two CSR-SDRs
- Remotely Controlled with App on Android Cell Phones

USB-SDR General Specs

- RF Transmit Power 2Watts
- >100Kbps Uplink (USB/STDN)
- >6Mbps Downlink
- Full Duplex



TDRS-MA Transponder

CubeSat Communications Payload

- **No Ground Terminal Required**
- **Constant Communications Link to Space Vehicle any where on orbit**
- **Utilized exiting NASA infrastructure**
- **TRL-7/Scheduled to Fly 2011**
- **PnP SPA-U Interface**

TDRS-MA (LEO/GEO)

- Low Data Rate
- Medium BER
- Low Latency
- High Availability
- LEO and MEO Vehicles

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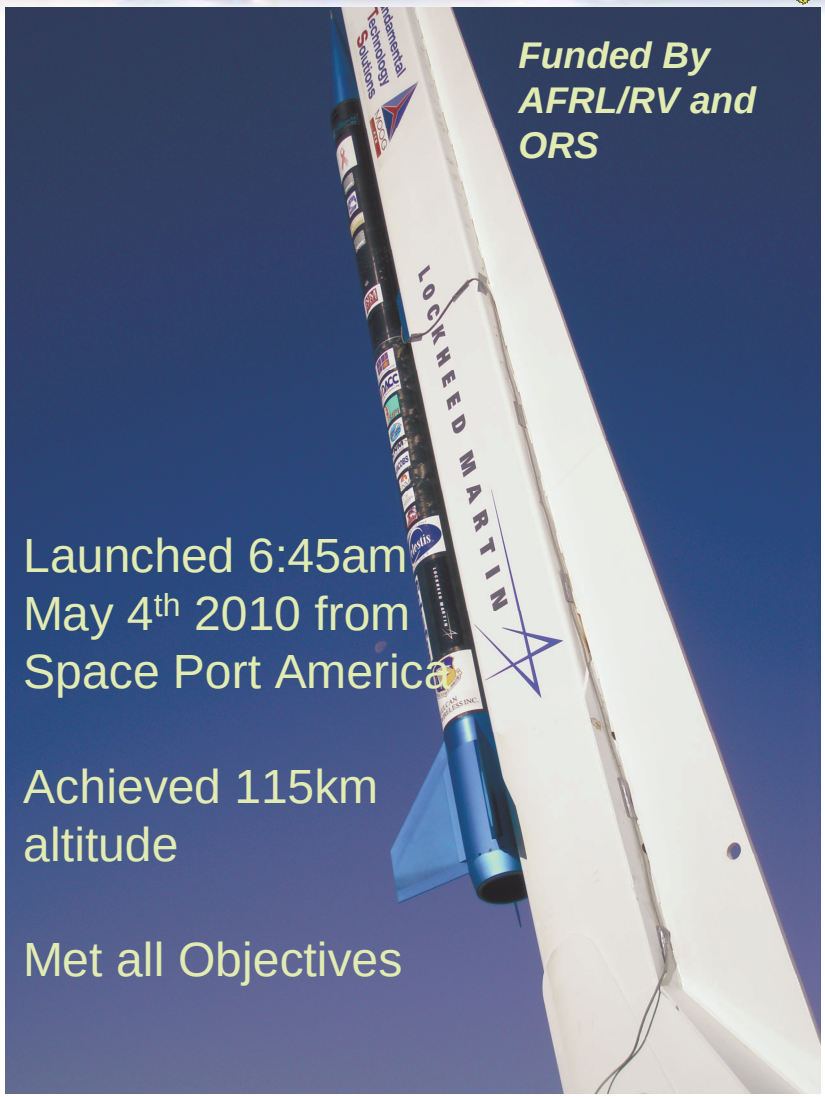
Sounding Rocket Experiment

Objective of Experiment

- Host on Hypersonic Flight Vehicle
- Demonstrate Space Vehicle Black Box Transponder Capability
- Close Link to GEO TDRS-MA
- Provided Real-Time Payload Telemetry to Ground



Funded By AFRL/RV and ORS

Launched 6:45am May 4th 2010 from Space Port America

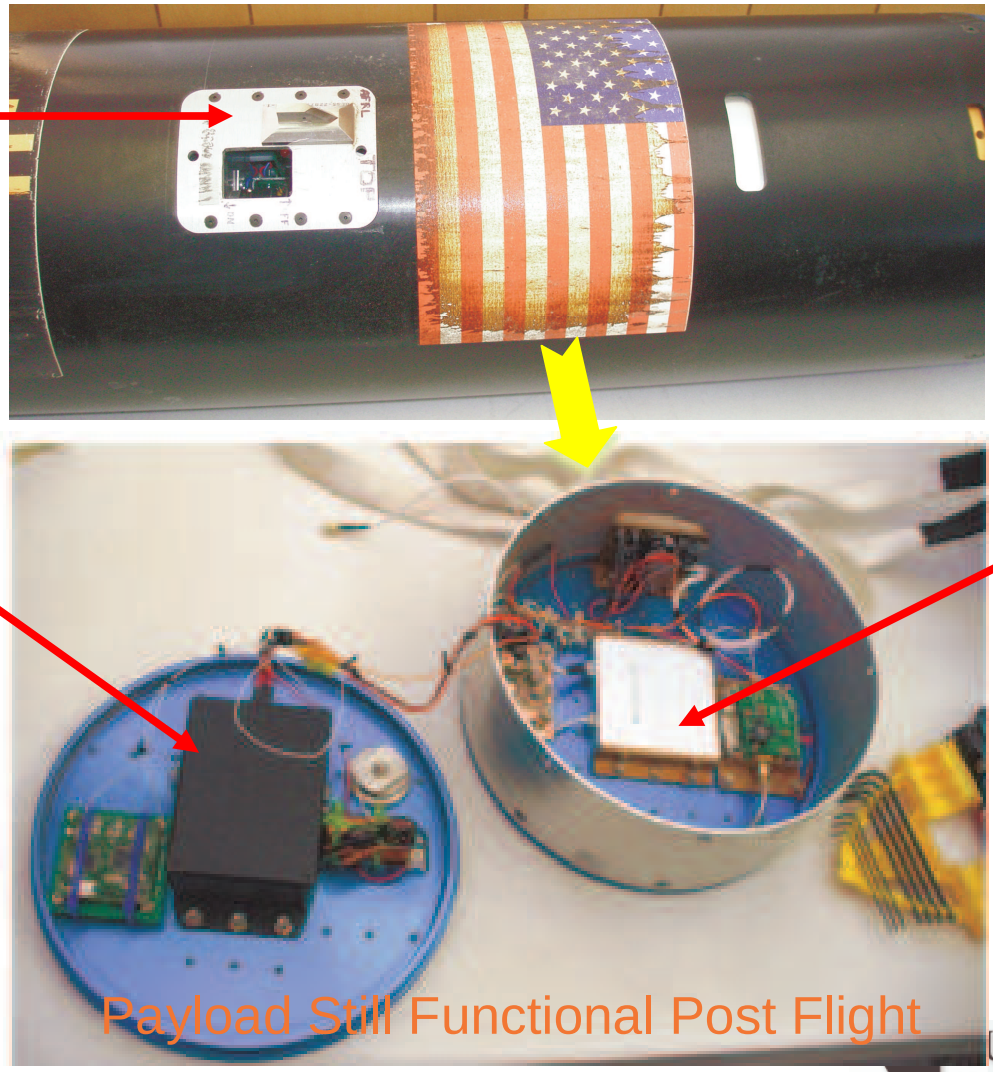
Achieved 115km altitude

Met all Objectives

Launch

Successful Launch and Demonstration of CSR-SDR-S Payload on May 4th 2010 at 6:45am

CSR-SDR Flown on Sounding Rocket



Conclusion

- Questions